



Comment

Patterned distributed populations: Beyond Turing  
Comment on: “Phase separation driven by density-dependent  
movement: A novel mechanism for ecological patterns” by  
Quan-Xing Liu et al.

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In their interesting work [1] the authors present the so far underexplored relevance that phase separation phenomena driven by density-dependent movement might have within an ecological context. The authors hypothesize that many spatio-temporal patterns observed in different ecological scenarios could be associated to a dynamics well described by Cahn–Hilliard like equations. The presentation of various examples aims to support the central idea of this work and leaves it clear that so far, the described process has been neglected as being responsible for the formation of such patterns.

Though the authors have gathered an extensive evidence in favor of their ideas, there is still place for the debate. A first criticism that can be done to the authors is that they have neglected the discussion about some other ideas that go beyond the Turing patterns and could be as plausible as the density dependent movement on trying to explain the origin of spatio-temporal patterns in distributed populations.

As an example, it is worth mentioning that throughout the last years there have been several studies that point to stress the importance of non-locality when considering the interactions between individuals of a population [2–5]. The non-local effects are associated to a bounded interaction radius and are responsible for the formation of spatial patterns in the distribution of a population. Besides the characteristic length of the patterned structures, the involved evolution time is also a critical indicator. In the mentioned case, the associated characteristic times defining the transient duration in steady situations or the period in spatio-temporal patterns are mediated by the motility of the individuals, making them comparable to what happens in a movement mediated phase separation. Though the path from the homogeneous state to patterns is via the unstabilization of the former one, the underlying mechanism is different from the one associated to Turing, as there is no need of two populations (activator and inhibitor). It is mediated only by the range of the interactions between individuals. These examples consider different non-local terms that can be associated to a FKPP or a Nagumo equations. The last case incorporates a well known ecological concept, the Allee effect, that can be linked to several examples of spatial and spatio-temporal pattern formation in the distribution of populations [6].

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The examples provided by the authors are intended to support the affirmation that the cause underlying the observed patterns is the active movements of the individuals in the involved population. However, the movement and its relation with the change in densities is then regarded as the cause when sometimes is just the effect. While the patterned distribution of blue mussel populations provides a perfect example for the application of the Cahn–Hilliard equations, the validity of the rest of the cases is arguable. For example, it has been argued that many of the observed patterns in animal movement respond to foraging strategies [7–11]. Several studies about fission–fusion dynamics in mammals populations, including the study of the subgroup size, its dispersion, and its composition consider that the complexity of the foraging strategy and the effect of dyadic interactions are the basis of the observed pattern. Rather than a movement governed by the density of the group, these works tend to explain the changes in group size as the results of individual decisions, exploring behavior and dyadic interactions. As expressed before, the change in population density is regarded as the effect rather than the cause. Those studies suggest that the individual choice among different movement modes is governed by a combination of factors, including internal states, memory, motion constraints, and landscape characteristics. In other words, studies in groups of foxes, spider monkeys and elks suggest that the dynamics of the grouping and dispersion responds to foraging strategies and exploration–exploitation balance and need not be generated by density dependent movements mechanisms.

The observation of cemetery formation in ant colonies described in [12] suggests the occurrence of a local activation and long-range inhibition mechanism based on individual worker behavior. The observed results were accurately described by a reaction–diffusion model incorporating the characteristics of the individual behavior of the ants. Further observations about the influence of the temperature on the ants activity [13] support the idea of the existence of a long range inhibition mediated by pheromone signaling.

In summary, the formulation of ecological model equations based on Cahn–Hilliard is an interesting approach to systems where the dynamics is certainly governed by density dependent movements. However, some care should be taken in not screening the real underlying aspect that can display patterned distributions rooted in more fundamental interactions and mechanisms and where the density dependent movement is only an emergent manifestation but never the cause. On the other hand, the authors have a strong case when suggesting that mechanisms others than those associated to Turing pattern should be considered. The phase separation driven by density dependent movements is a plausible one, though its ubiquity should be declared with caution. As expressed by the authors in their work, the density dependent movement in ecology has not been so far thoroughly explored while it could undoubtedly be a source of new knowledge about patterns formation in distributed populations.

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